PATENT SPECIFICATION

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750,305

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COMPLETE SPECIFICATION

Improvements in Axial-flow Compressor, Turbine and like Blades

We, ROLLS-ROYCE LIMITED, whose Registered Office is at Nightingale Road, Derby, in the County of Derby, England, a British Company, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to axial-flow compressor, turbine and like blades.

The object of the invention is to provide axial-flow compressor, turbine and like blading giving improved efficiency in operation particularly at low speeds.

According to the present invention an axial-flow compressor or turbine blade is provided with one or more blind recesses in one or both faces, interrupting the otherwise normal blade surface and extending spanwise of the blade, whereby in the operation of the axial-flow machine of which the blade forms part, the boundary layer flow over the blade face or faces is caused to become turbulent at a point in chordal section of the blade which is upstream of the location at which the laminar flow separation point would occur without the presence of such recess or recesses.

In using the expression "blind recesses" we mean that the recess is open only on the surface of the blade and does not communicate with the blade interior and in speaking of the "otherwise normal" blade surface we imply that the blade surface does not have projections or interruptions other than the recess or recesses to affect the smooth flow of the boundary layer there over.

Under conditions of laminar flow of gas over a normal blade a boundary layer builds up adjacent the surface of the blade due to viscous forces acting between adjacent layers of the gas. There is thus normally a smooth laminar boundary layer flow over a portion of the surface extending chordwise from the leading edge of the blade, the thickness of the boundary layer increasing whilst maintaining laminar flow until ultimately a break-away occurs resulting in large eddies over the rear portion of the blade. This may occur more particularly at low speeds and detracts from the aerodynamic efficiency of the blade. The point at which such break-away takes place is normally known as the laminar flow separation point.

An example of this invention is illustrated in the drawings accompanying our Provisional Specification.

Fig. 1 shows a chordal section of a normal blade;

Fig. 2 is a like section of a blade according to this invention;

Fig. 3 is an enlarged view of the groove shown in Fig. 2.

In Fig. 1 a normal turbine blade is illustrated in which such laminar boundary layer flow is shown together with the laminar flow external to the boundary layer disturbed by the large eddy conditions after break-away. In this figure the blade is illustrated at 10, the smooth laminar boundary layer flow is indicated at 11 and the external laminar flow is indicated at 12. At the laminar flow separation point 13 break-away occurs causing large eddies at 14 over the rear portion of the blade.

In the blade shown in Fig. 2 and in Fig. 3 a recess is provided in the upper surface in accordance with the invention in the form of a groove 15. In these figures the blade section is again shown at 10, the laminar boundary layer flow over the leading portion of the blade at 11 and the external laminar flow at 12. The groove 15, which is conveniently formed to have a sharp edge at 15A and a smooth run into the rear portion of the blade at 15B (see Fig. 3), is located at a point in chordal section of the blade upstream of the laminar flow separation point shown at 13 in Fig. 1. This interrupts the build-up of the thickness of the laminar flow boundary layer

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which would ultimately cause the break-away shown in Fig. 1. The recess introduces turbulence into the boundary layer and changes the character of the boundary layer flow from laminar to turbulent, the latter type of flow being shown at 11A. Thus turbulent flow exists over the rear portion of the blade and the build-up of this boundary layer may be insufficient to cause a break-away over the rear portion of the blade, giving rise to large eddies. Losses due to such large eddies occurring with a normal blade as shown in Fig. 1 may be avoided.

Whilst normally for convenience of manufacture the groove 15 is provided by a continuous channel, extending along the full spanwise length of the blade or along part of the spanwise length of the blade, equivalent formations may be used, such as for example would be provided by a line of discontinuous recesses extending spanwise of the blade such recesses being sufficiently close to one another to provide an arrangement functioning in a manner similar to that of a groove.

It will be appreciated that in the illustration of the accompanying drawing the dimensions, e.g. as to the thickness of the gas layers and the location and extent of the disturbed flow are purely examplary and are not to be taken as represented to scale.

It will also be appreciated that a groove corresponding to the groove 15 could be formed in the lower face to have the like effect to cause the boundary layer over that face to become turbulent before the laminar flow separation point.

What we claim is:—

1. An axial-flow compressor or turbine blade which is provided with one or more blind recesses in one or both faces interrupting the otherwise normal blade surface and extending spanwise of the blade whereby in operation of the axial-flow machine of which the blade forms part the boundary layer flow over the blade face or faces is caused to become turbulent at a point in the chordal section of the blade which is upstream of the location at which the laminar flow separation point would occur without the presence of such recess or recesses.

2. A blade as claimed in Claim 1 in which there is a single recess in the form of a groove in the upper face of the blade.

3. A blade as claimed in Claim 1 in which there is a line of discontinuous recesses extending spanwise of the blade such recesses being sufficiently close to one another to provide an arrangement functioning in a manner similar to that of a groove.

4. A blade as claimed in Claim 1 in which the recess has a sharp leading edge but at the trailing side runs smoothly into the blade surface.

5. An axial-flow compressor or turbine blade having means for causing the boundary layer of air flowing over it to become turbulent upstream of the laminar flow separation point substantially as described with reference to Figs. 2 and 3 of the drawing accompanying the Provisional Specification.

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PROVISIONAL SPECIFICATION

Improvements in Axial-flow Compressor, Turbine and like Blades

We, ROLLS-ROYCE LIMITED, of Nightingale Road, Derby, a British Company do hereby declare this invention to be described in the following statement:—

This invention relates to compressor, turbine and like blades for axial-flow turbo-machines.

The object of the invention is to provide compressor, turbine and like blading for axial-flow turbo-machines giving improved efficiency in operation particularly at low speeds.

According to the present invention a compressor, turbine or like blade for an axial-flow turbo-machine is provided with a recessed interruption in one or both faces, extending spanwise of the blade, for the purpose of causing the boundary layer flow to become turbulent at a point in chordal section of the blade which is upstream of the location at which the laminar flow separation point would occur in the operation of the turbo-machine without the presence of such interruption.

Under conditions of laminar flow of gas over a normal blade a boundary layer builds up adjacent the surface of the blade due to viscous forces acting between adjacent layers of the gas. There is thus normally a smooth laminar boundary layer flow over a portion of the surface extending chordwise from the leading edge of the blade, the thickness of the boundary layer increasing whilst maintaining laminar flow until ultimately a break-away occurs resulting in large eddies over the rear portion of the blade. This may occur more particularly at low speeds and detracts from the aerodynamic efficiency of the blade. The point at which such break-away takes place is normally known as the laminar flow separation point, and in Fig. 1 of the accompanying drawing a normal turbine blade is illustrated in which such laminar boundary layer flow is shown together with the laminar flow external to the boundary layer disturbed by the large eddy conditions after break-

away. In this figure the blade is illustrated at 10, the smooth laminar boundary layer flow is indicated at 11 and the external laminar flow is indicated at 12. At the laminar flow separation point 13 break-away occurs causing large eddies at 14 over the rear portion of the blade.

In Fig. 2 and in Fig. 3 in enlarged view a chordal section of a turbine blade is illustrated having an interruption in the upper surface in accordance with the invention in the form of a groove. In these figures the blade section is again shown at 10, the laminar boundary layer flow over the leading portion of the blade at 11 and the external laminar flow at 12. The groove 15, which is conveniently formed to have a sharp edge at 15A and a smooth run into the rear portion of the blade at 15B (see Fig. 3), is located at a point in chordal section of the blade upstream of the laminar flow separation point shown at 13 in Fig. 1. This interrupts the build-up of the thickness of the laminar flow boundary layer which would ultimately cause the break-away shown in Fig. 1. The interruption introduces turbulence into the boundary layer and changes the character of the boundary layer flow from laminar to turbulent, the latter type of flow being shown at 11A. This turbulent flow exists over the rear portion of the blade and the build-up of this boundary layer may be insufficient to cause a break-away over the rear portion of the blade giving rise to large eddies. Losses due to such large eddies occurring with a normal blade as shown in Fig. 1 may be avoided.

Whilst normally for convenience of manufacture the groove 15 is provided by a continous channel, extending along the full spanwise length of the blade or along part of the spanwise length of the blade, equivalent formations may be used, such as for example would be provided by a number of drilled recesses disposed adjacent one another in a line extending spanwise of the blade, such recesses being sufficiently close to one another to provide an arrangement functioning in the manner similar to that of a groove.

It will be appreciated that in the illustration of the accompanying drawing the dimensions e.g. as to the thickness of the gas layers and the location and extent of the disturbed flow, are purely examplary and are not to be taken as represented to scale.

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750,305 PROVISIONAL SPECIFICATION
1 SHEET

This drawing is a reproduction of the Original on a reduced scale.

Laminar Strömung
äußere Begrenzung

FIG. 1.

Laminarstrom-ablösung

Wirbel am Schaufelteil

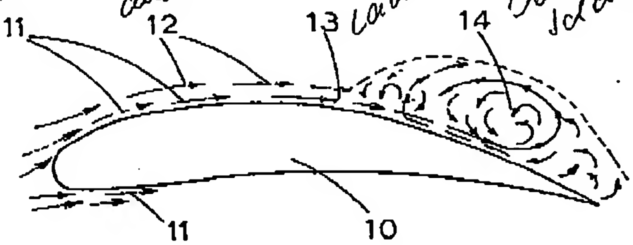
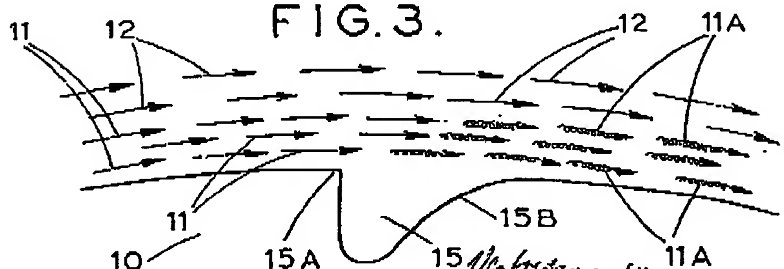
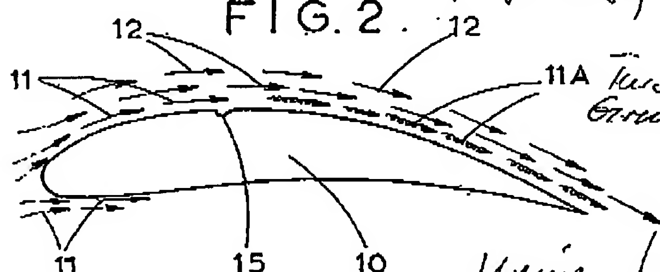


FIG. 3.



Vertiefung (Rille)

FIG. 2.



Turbulenzen in Grenzschicht.

keine Grenzschicht-ablösung, keine Wirbel